were in process of final liquefaction. Certain elements of the geological situation recently developed by American scientists, and already touched upon in this paper, necessarily enter as essential factors into the solution of the problem before us. The following is a summarized recapitulation of glacial principles enunciated by authorities now engaged in deciphering the ice chronicles of the Northwest:

That this whole region has been subjected to a period or periods of glaciation antedating the last.

That a longer or shorter era of deglaciation, known to scientists as an interglacial epoch, intervened between the deposit of the older tills and the readvance of the northeast and northwest glaciers during the latest ice period.

That the general direction of glaciation was similar during the earlier and later ice epochs, though it was not always precisely the same.

That glaciation was far more extended in its range at the former of these periods than at the latter; the ice of the former having stretched fully three hundred miles south of the termini of the modern morainic lobes.

That the modern morainic belt defines the limit of extension of the glaciers during the last ice epoch.

Finally, that the Little Falls quartz stratum lies between the modern moraines of the northeast and northwest glaciers, in a medial morainic belt which is characterized by a system of overlapping tills, as described in Mr. Upham's paper at the close of this article.

The above elements sum up the glacial situation as understood by specialists, so far as concerns the quartz stratum under consideration. The tills of Morrison county have, up to the present time, not been fully reported upon, and their special interrelations are accordingly very imperfectly understood.

(To be continued.)

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THE GENESIS OF CRYSTALLINE ROCKS.[1]

BY T. STERRY HUNT, LL.D., F.R.S.

THE writer began by an account of the various hypotheses hitherto proposed to explain the origin of the ancient crystalline stratified rocks, of which gneiss may be taken as the type,

[1] Abstract of a paper read before The National Academy of Sciences, April 15, 1884.

(1.) The *plutonic* hypothesis, which conceives the rocks in question to have been formed by the superficial cooling of a molten globe before the precipitation of water upon its surface. (2.) The *volcanic* hypothesis, which supposes them to be derived from igneous rocks, like lavas, coming from a liquid interior through the primitive crust. (3.) The detrital or *clastic* hypothesis, which conceives them to have been made of the ruins of plutonic or volcanic rocks, more or less disintegrated or decayed, rearranged by water, and subsequently modified by chemical changes. Similar alterations, through subsequent action of water, are also invoked by the advocates of the plutonic and volcanic hypotheses. (4.) The *chaotic* hypothesis, which supposes the elements of all these rocks to have been at one time dissolved or suspended in the water of a primitive chaotic ocean.

The difficulties in the way of accepting any one of these hypotheses being pointed out, it was shown that the rocks in question include a number of well-marked and lithologically distinct groups, each of great thickness, giving evidences of successive depositions interrupted by foldings and erosions, and extending over vast periods of eozoic time. The new hypothesis proposed by the writer to explain the origin of these rocks, unlike the first three named, starts from the basis of a solid earth. The globe consolidating at the center, left, it is conceived, a superficial layer of basic silicates, which has yielded all the fixed elements of the earth's crust. This layer formed the first land and the floor of the primeval sea, the acid waters of which, permeating and partially decomposing it, became thereby chemically neutralized. This last-cooled layer, mechanically disintegrated, saturated with water, and heated by the central mass, was the source of mineral springs holding in solution the silicates which built up the ancient gneisses and similar rocks.

This hypothesis of their origin was illustrated by the history of granitic veins, and by the derivation of quartz and orthoclase, and of zeolites (which are hydrated feldspars) by aqueous action from basic rocks. All such deposits are due to survivals of the process which generated the gneissic rocks. The hypothesis of their formation from materials brought to the surface by mineral springs from the primitive basic layer, affords, it was claimed, the elements of a complete and intelligible explanation of the origin of the eozoic rocks, and was first suggested by the

writer in 1874 (Chemical and Geological Essays, pp. 298, 299). It may be conveniently designated as the *crenitic* hypothesis (from the Greek κρηνίτης, pertaining to springs or fountains). All veinstones and deposits from mineral springs are of crenitic origin.

It was farther shown that the upward lixiviation of the primitive mass, and the deposition over it of an acidic granite-like rock would leave below a highly basic material, and that the division of the mass thus established would correspond to that of the trachytic and doleritic magmas which have been conjectured to be the sources of two great types of eruptive rocks. Inasmuch, however, as according to the present hypothesis these two layers of basic and acidic matters are the results of aqueous action, and not of an original separation in a plutonic mass, as imagined by Phillips and Durocher, their composition would be subject to many local variations. The secondary origin of the materials of eruptive rocks has long been maintained by the writer, who finds the source of certain of them in the underlying basic layer left by the partial solution of the primitive mass; which now forms, it is believed, a plastic stratum between the solid anhydrous nucleus and the solid crust.

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EDITORS' TABLE.

EDITORS A. S. PACKARD, JR., AND E. D. COPE.

—— Professor A. Weisman, who has recently published a brochure on inheritance, and another on the duration of life, has now attacked from the biological, *i.e.* inductive point of view, those ultimate problems which so often arise in the minds of thoughtful men, What is life and death? His tract was when first read as an academic programme, entitled "On the Perpetuity of Life." It is claimed by the author that in the protozoa, or one-celled animals, we cannot speak of a natural death in connection with these lowest organisms, for there is no observable end to their phases of development which is comparable to the death of the higher, many-celled animals. In the protozoa there is no origin of new individuals resulting in the death of the parent, but as seen in the self-division of any infusorian, neither of the new individuals is the older or younger. Thus there arises an unending series of individuals, each one of which is as old as the species itself, each